Ultra-Lightweight Optical Quality Deployable Mirrors

Completed Technology Project (2013 - 2016)

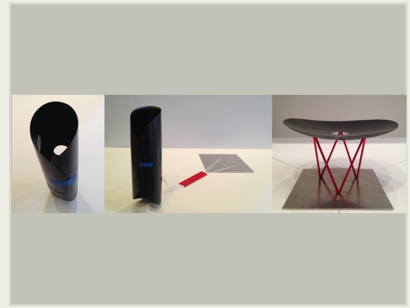
Project Introduction

Objective is to develop and demonstrate ultra-lightweight, deployable, optical quality Carbon Shell Mirrors (CSMs), leading to high-quality, low-cost space telescopes. Will enable low cost, replicated mirrors and mirror segments, with ultra-low mass areal density, with individual mirrors scaling to meter size. In support of the objective of ultra-lightweight, low-cost segmented space telescopes, a compact high dynamic range primary mirror co-phasing technique was also developed. Sample cube-sat mission was designed and 3D printed.

1) This research will demonstrate mirrors with a diameter of up to 40 cm, with post-control wavefront error less than 100 nm, and surface microroughness less than 5 nm. It will demonstrate Wavefront Sensing and Control (WFSC) dynamic range adequate to capture post-deployment figure errors up to 1 mm, with ultimate WFS&C error of 10 nm. The goal for the deployable mirrors volume prior to deployment is an envelope of 10 cm x 10 cm x 20 cm; an example cone-fold packaging scheme is shown in Fig. 1. The goal for the mass areal density of the mirrors is < 1 kg/m^2. The goal for the actuator areal density is >5,000/m^2.   2) The state of the art in lightweight space optics is the Actuated Hybrid Mirror (AHM) jointly developed by JPL/LLNL/Xinetics, which exhibits better performance than the goals listed above but with significantly greater areal density and without the ability to be folded or rolled for deployment. More conventional glass optics are even heavier, and lack correctability. Commercial deformable mirrors are available from multiple vendors, but are generally flat, heavy, not deployable, and not free-standing. The state of the art for high dynamic-range wavefront sensing is the reverse-Hartmann methods developed and demonstrated at U. of Arizona for fabrication of large (4m+) glass mirrors.

Anticipated Benefits

Visible-quality, deployable, small telescope optics will enable extremely low-cost CubeSat or SmallSat space telescopes to provide SMEX-class optical performance, with apertures in the 18-40 cm range. For Earth Science, applications include imaging to address Solid Earth priorities, including geomorphology and seismology. For Astrophysics, small mission possibilities include spectrometry for stellar variability and exoplanet transit photometry. Large apertures, in the 8-16 m size range, have been identified as a priority for NASA astrophysics, and for other missions as well. For larger mirrors, CSMs offer the long-term potential for dramatically lower mass than conventional glass or even SiC mirrors. This is especially true especially for large segmented telescopes, where mirror mass is multiplied many times by support structures. CSMs will also be much lower cost than conventional mirrors – a virtue of replication-based manufacturing.



Ultra-lightweight deployable deformable (active) mirror made of carbon shell fibers using thin PMN layers for electronic actuation.

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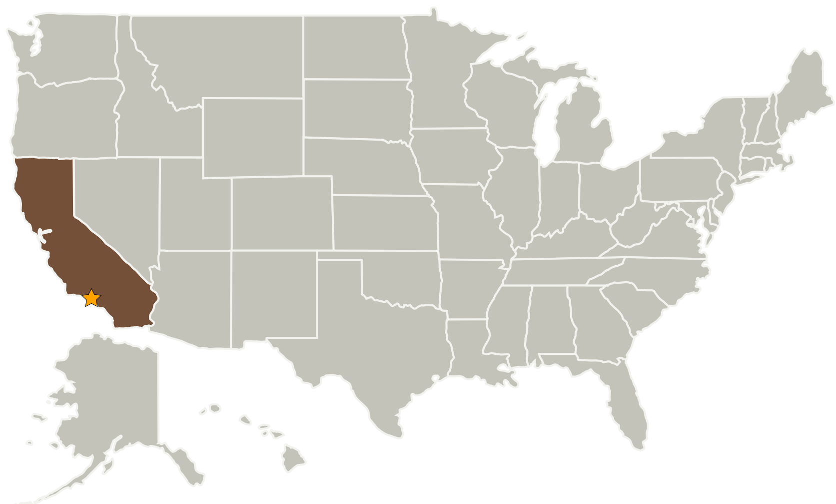
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Jet Propulsion Laboratory(JPL)	Lead Organization	NASA Center	Pasadena, California
California Institute of Technology(CalTech)	Supporting Organization	Academia	Pasadena, California
Lawrence Livermore National Laboratory(LLNL)	Supporting Organization	R&D Center	Livermore, California

Primary U.S. Work Locations
California

Images

Ultra-Lightweight Optical Quality Deployable Mirrors
(https://techport.nasa.gov/image/)

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Jet Propulsion Laboratory (JPL)

Responsible Program:

Center Independent Research & Development: JPL IRAD

Project Management

Program Manager:

Fred Y Hadaegh

Project Manager:

Fred Y Hadaegh

Principal Investigator:

Scott A Basinger

Co-Investigators:

Sergio Pellegrino
David C Redding
John B Steeves
Kent T Wallace

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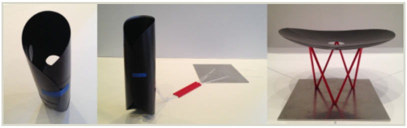
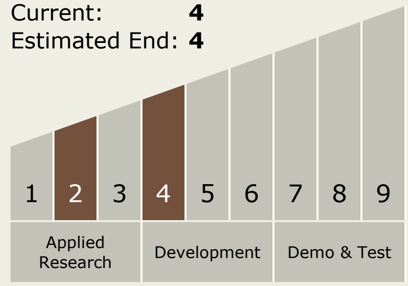


Ultra-Lightweight Optical Quality Deployable Mirrors
Ultra-lightweight deployable deformable (active) mirror made of carbon shell fibers using thin PMN layers for electronic actuation.
(https://techport.nasa.gov/image/26102)

Technology Maturity (TRL)

Start: **2**
Current: **4**
Estimated End: **4**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.2 Observatories
    └ TX08.2.1 Mirror Systems